Draft

Summary Report

Tacoma Smelter Plume
Phase II, Child Use Area Study
King County, Washington

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EXECUTIVE SUMMARY

From 1890 to 1986 a lead and copper smelter operated in Ruston, Washington, a small community northwest of Tacoma. The property has been owned by American Smelting and Refining Company, Asarco, since 1905. The Asarco Smelter refined lead and copper from ores and concentrates which were shipped from other locations. It specialized in smelting of high arsenic ores.

Since the early 1970's numerous studies have been performed associating the Asarco Smelter with environmental contamination. The smelter property and surrounding approximately one square mile area were placed on the U.S. Environmental Protection Agency National Priority List of hazardous waste sites in the early 1980's as part of the Superfund cleanup process. Cleanup began in the early 1990's and completion is expected to be accomplished in 2006. A number of studies have documented regional arsenic and lead contamination from smokestack emissions in an area several hundred square miles downwind of the smelter. The Department of Ecology (Ecology) designated the area the Tacoma Smelter Plume Site under Washington's Model Toxics Control Act (MTCA) in 1999.

Ecology, in association with local health departments, community members and industry representatives, funded a number of studies to characterize the contamination in the Tacoma Smelter Plume. Studies have been performed in Pierce, King, Kitsap, and Thurston Counties. This Phase II Child Use Area Study provides arsenic and lead soil concentrations in areas where children are most likely to be exposed to soil in southwest King County and its suburbs.

Nearly 30 percent of the child use area properties sampled in this study had arsenic and or lead results above cleanup levels. Arsenic was detected above the state cleanup level of 20 mg/kg in 5.2 percent of the samples collected. The maximum arsenic concentration reported was 223 mg/kg. Lead was detected above the state cleanup level of 250 mg/kg in less than one percent of the samples collected. The maximum lead concentration reported was 660 mg/kg.

Slightly higher concentrations of both arsenic and lead were found in the surficial 0-2 inch depth samples than in the 2-6 inch depth samples. The average arsenic concentration for all samples was 9.1 mg/kg at 0-2 inches and 7.7 mg/kg at 2-6 inches. The average lead concentration for all samples was 27.1 mg/kg at 0-2 inches and 23.85 mg/kg at 2-6 inches.

Large scale spatial patterns of elevated concentrations of arsenic and lead in soil caused by air deposition from the Asarco Smelter were found to be variable on a local scale. Areas of 0-20 mg/kg are intermixed with areas 20-100 mg/kg.

Letters were sent to property owners listing the laboratory results for samples collected on their property. The letter also described the state cleanup levels, the health risks, and soil safety guidelines developed by PHSKC. The guidelines advise property owners of ways to take precautions to reduce risk of exposure to contaminated soil. Contact telephone numbers of Ecology and PHSKC staff were provided in the letter for property owners who desire further guidance.

Given that contamination was identified on approximately 30 percent of the properties sampled and that there are a significant number of child use areas that have not been sampled, it is reasonable to assume that a significant risk of exposure to children and the public still exists within the TSP. PHSKC recommends that sampling, education and outreach efforts to child use areas and owners continues.

Summary Report
Tacoma Smelter Plume, Phase II Child Use Area Study
King County, Washington

1. INTRODUCTION

From 1890 to 1986 a lead and copper smelter operated in Ruston, Washington, a small community northwest of Tacoma. The property has been owned by American Smelting and Refining Company, Asarco, since 1905. The Asarco Smelter refined lead and copper from ores and concentrates which were shipped from other locations. The by-products were refined to produce arsenic, sulfuric acid, liquid sulfur dioxide and slag. It specialized in smelting of high arsenic ores. For many years it was the sole domestic supplier of arsenic in the United States.

Since the early 1970's numerous studies have been performed associating the Asarco Smelter with environmental contamination. The smelter property and surrounding approximately one square mile area were placed on the U.S. Environmental Protection Agency National Priority List of hazardous waste sites in the early 1980's as part of the Superfund cleanup process. Cleanup began in the early 1990's and completion is expected in 2006. A number of studies have documented regional arsenic and lead contamination from smokestack emissions in an area several hundred square miles downwind of the smelter. The Department of Ecology (Ecology) designated this area the Tacoma Smelter Plume Site under Washington's Model Toxics Control Act (MTCA) in 1999.

Ecology, in association with local health departments, community members and industry representatives, funded a number of studies to characterize the contamination in the Tacoma Smelter Plume. Studies have been performed in Pierce, King, Kitsap, and Thurston Counties. This Phase II Child Use Area Study provides arsenic and lead soil concentrations in areas where children are most likely to be exposed to soil in southwest King County and its suburbs.

1.1 Involved Parties

Public Health – Seattle & King County (PHSKC) has completed the Phase II Child Use Area (CUA) Study of the Tacoma Smelter Plume in a defined study area in southwest King County, Washington. The Phase II CUA Study completes the Tacoma Smelter Plume Mainland King County, Washington, Child Use Area study started by Science Applications International Corporation (SAIC, 2003). The work was conducted under contract G0400087 from Ecology.

1.2 Purpose

The general objective of this Phase II CUA study was to evaluate and sample child use areas which were previously identified in the Mainland King County CUA study completed by SAIC in June, 2003. The SAIC CUA study was designed in a collaborative effort between Ecology, PHSKC, SAIC, Tacoma Pierce County Health Department (TPCHD), and private consultant Gregory L. Glass. SAIC sampled 97 of the approximately 600 child use areas which were identified by PHSKC and Ecology at that time. The Sampling Design, Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) were updated for this project. The purpose of the Phase II CUA investigation was to collect additional soil arsenic and lead data to better define the magnitude and extent of contamination and further assess future actions within the Tacoma Smelter Plume.

1.3 Scope of Work

The scope of work as described in the Grant Agreement G0400087, was in accordance with design plans and included the following tasks:

- Review and update planning documents as necessary: QAPP, FSP, and Health and Safety Plan (H & SP).
- Evaluate the identified child use facilities using current property ownership records and interviews with operators to determine the exposure potential for children.
- Obtain access authorization agreements from property owners.
- Evaluate physical site setting and collect soil samples following established sampling criteria.
- Document field sampling activities.
- Review laboratory results.
- Perform quality control and data assessment procedures.
- Develop a King County database for generated information with interface ability to Ecology's Environmental Information Management (EIM) system.
- Preparation of a summary report.

Laboratory analysis was performed by Severn Trent Laboratories (STL) in Tacoma, Washington under contract with TPCHP. Due to budget constraints limited data validation reviews were performed by PHSKC not an outside laboratory. The scope of this project does not include Public Education and Outreach efforts by PHSKC in the Tacoma Smelter Plume. Characterizing impacts from other potential sources of arsenic or lead, such as treated wood, paint, or leaded gasoline emissions was not the objective of this study.

2. STUDY DESIGN

2.1 Study Area

In 2002 the boundaries of the Child Use Area study were determined by a Study Design Group with representatives from Ecology, PHSKC, TPCHD, and Gregory L. Glass, an independent consultant (SAIC, 2003). The Study Design Group analyzed data from previous investigations to estimate delineation where concentrations of maximum soil arsenic levels above 100 mg/kg potentially exist. The study area is bound on the north by the West Seattle Highway, the Pierce County border to the south, Puget Sound to the west, and approximately Highway 167 to the east. It includes the communities of: Algona, Auburn, Burien, Covington, Des Moines, Federal Way, Kent, Normandy Park, Renton, SeaTac, Southwest Seattle, Tukwila, and Vashon Island.

2.2 Identified Child Use Areas – Site Listing

Young children are considered a population of special concern because of their natural tendency for soil contact and ingestion and the greater risk of exposure to smelter-related contaminants such as lead. Therefore, the focus of this study and previous child use area studies was in areas where there was a potential for young children to be exposed to arsenic and lead in contaminated soils.

PHSKC and Ecology created the original listing of child use areas which included parks, elementary schools, preschools, childcare centers, camps, vacant lots, and community gardens. Properties sampled

during the SAIC 2003 study were removed from the listing and it was then updated to include: eight Vashon Island childcare facilities, 13 King County Parks, four Seattle Parks, and 107 mainland childcare facilities. The Phase II CUA final listing included 547 properties.

Letters and access agreements describing the study and seeking permission to collect samples were sent to property owners in two bulk mailings, once in August, 2004 and once in March, 2005.

Table 1: Site Types, Total of 547

Number	Type
41	Parks
10	Private Schools
16	Public Elementary Schools
4	Community Centers
2	Vacant Lots
2	Camps
85	Child Care Centers
387	Private Home Childcare Facilities

2.3 Access Agreements

Responses to the letter and access agreements expressing a willingness to participate in the study were received from 100 property owners or operators. Participants were contacted and sampling visits were scheduled. PHSKC staff also contacted or attempted to contact property owners that did not respond to the August, 2004 mailing with follow-up phone calls and/or property visits. PHSKC visited ninety properties where the owner did not respond to the mailing and phone numbers could not be found. Properties whose owners did not respond to attempts to contact them either by phone or site visits were moved to a declined/inactive status. Declined or inactive indicates they were either no longer childcare facilities, the owner declined to participate or didn't respond, or the child use area did not meet the sampling criteria. Of the 547 total properties, 364 were declined or inactive. At the time of this report 91property owners had not responded to letters that were mailed in March. Original access agreements were placed in project files and copies were kept on site during field activities.

PHSKC sampled 91 parks, public elementary schools, private schools, children's centers and private home child care facilities as shown in Table 2.

Table 2. Types of Properties Sampled, Total of 91

Number	Type of Child Use Area
31	Parks
8	Public Elementary Schools
3	Private Schools
9	Child Care Centers
40	Private Home Childcare Facilities

2.4 Decision Units

Child –use area properties were subdivided by the field staff into "Decision Units" by evaluating exposure risk and type of use. Decision Units (DU) reflected different activities, land uses, and geographic distribution with relatively homogeneous activities and development histories. Owners and staff were consulted to evaluate the property use. The rationale for dividing properties into DU's was that DU's offered the option of different response actions for different areas of the property if elevated levels of contaminants were found. Examples of single DU's include: playgrounds, baseball fields, soccer fields, and open fields.

Following the study design, properties were divided into a maximum of four DU's to promote sampling at a larger number of properties; although four DU's were not required on each property. DU sizes were a minimum of 100 square feet and a maximum of approximately one acre as specified by the study design. The number of DU's, their size and distribution were at the discretion of the field staff. For instance, small childcare facilities at residential homes often had one child use area in the backyard which was determined to be one DU. Conversely, given the restriction to four DU's, it was not possible to provide complete sampling coverage of very large park properties.

2.5 Borings

The study design specified a maximum of eight borings per DU with two samples from each boring; one sample from 0-2 inch and one from 2-6 inch. The design criteria allowed for fewer than eight borings. As in the example in the above section, four borings was often sufficient coverage in a small backyard play area. Distribution and number of borings were determined by field staff. Discrete samples were collected from each of the sampling depths. The soil surface was prepared for sample collection by removing all cover such as: wood chips, pea gravel, organic debris, duff, or grass prior to sampling.

Boring locations were prioritized first by potential for soil exposure and secondly by spatial distribution within the DU. The density of borings was greater in areas where soil contact was more likely. For instance at a playground with both exposed soil (possible traffic paths) and grass, boring locations were first distributed in exposed soil and the remaining borings were distributed for spatial coverage in the grass area. Effort was made to place borings in all parts of the DU where soil contact was possible, even if less likely.

2.6 Sampling Exclusions

Sampling locations were restricted to areas of accessible soil. Soils beneath buildings, pavement, patios, etc. were not sampled. Specific exclusion criteria included:

- 200' from Interstate highways
- 50' from railroad corridors
- 25' from major arterials
- 25' from power line or pipe line right of way
- 15' from minor arterial/street
- Five feet from treated wood structures
- Five feet from painted structures
- Areas with a barrier (i.e. Geotextile fabric, rubber mats)
- More than 12 inch cover material (i.e. wood chips, pea gravel)
- Clean sands were not sampled

3. FIELD ACTIVITIES

Field sampling activities were performed by a team of two PHSKC staff. Sample collection took place December, 2004 through May, 2005. After discussing site use with the owner or operator and evaluating child use areas, field staff determined decision units and boring locations. Safety meetings were held at the beginning of each day and field activities were recorded in field notebooks.

3.1 Sample Identification

Sample jars were labeled with unique identification numbers which included the site number, decision unit number, boring number, sample number, and type. See Table 3.

Table 3. Sample Naming Scheme

Designation	Assigned Value
Site Number	5000 through 5612
Decision Unit	A, B, C, or D
Boring Number	1 through 8
Sample Number	0-2 inch = A or 2-6 inch = B
Sample Type	Regular = 1; Duplicate = 2

For example:

Sample 5123A01A1 is Site number 5123, Decision Unit A, Boring 1, 0-2 inch depth, a regular sample.

Sample 5123C08B2 is Site number 5123, Decision Unit C, Boring 8, 2-6 inch depth, a duplicate sample.

The label also recorded the site name, time, date, sampler initials, company name, and type of analysis requested. All samples were analyzed for arsenic, lead, and moisture content.

3.2 Sample Equipment

Samples were collected using custom made heavy gage stainless steel coring tools. The cylindrical tools with a flat head and handle were driven into the ground with an approximately three pound mallet. Stainless steel spoons and knives were used to place the samples in the sample jars while working over a plastic covered work space. Field notebooks, Garmin GPS, and a compass were used to measure and record field data.

Field staff wore level D Personal Protective Gear: steel toed boots, leather and plastic gloves, long sleeve shirts, and orange reflective vests or rain gear. Safety glasses, ear protection, and first aid kits were also available. The Health and Safety and Field Sampling Plans were in field staff possession during all field operations.

3.3 Sample Collection

Previous studies found that in undisturbed soils arsenic, lead, and other smelter related metals were primarily located in the uppermost soils. Uppermost soils are also the soils which children are most likely to be exposed to, therefore, samples were collected from 0-2 inch and 2-6 inch at each boring. The following procedure was used when collecting samples:

- Create plastic covered work space
- Remove surficial vegetative material, duff, grass
- Drive in 0-2 inch coring device into ground with mallet
- Put on gloves
- Using stainless steel spoons or knife take sample from coring device or by scraping sidewall of boring
- Cap the sample, if not prelabeled, label it and record time
- Describe soils
- Drive 2-6 inch coring device
- Put on new gloves
- Using stainless steel spoons or knife take sample from coring device or by scraping sidewall of boring
- Cap the sample, if not prelabeled, label it and record time
- Describe soils.
- Place tools in decontamination bucket for cleaning.

- Bag up used gloves.
- Return the site to as close to original condition as possible
- Minimum of 1 duplicate sample per twenty samples.

After returning to the PHSKC office, soil color was determined and recorded in the field notebook using Munsell Soil Color Charts. Samples were compared to the field notebook and chain of custody forms were filled out.

3.4 Field notebook entries

Field notebook records were kept for all field work including: parcel number, address, date, time, staff names, weather, number of decision units, GPS coordinates and accuracy, sample depth, sample time, sample type, map of sample location, general soil description. Notes were kept recording activities, visitors, site descriptions, and all relevant observations during the sampling event.

Properties were sketched and the locations of all borings were mapped using compass bearings with paced distances to physical structures. The boring locations were also recorded with a Garmin GPS, datum WGS 1984.

3.5 Laboratory Analysis

Samples were analyzed for arsenic and lead by Severn Trent Laboratory (STL) in Fife, Washington. STL provided the sample jars, coolers, blue ice, and chain of custody forms.

Prior to digestion, the entire soil sample was removed from its container, sieved through a 2mm sieve, and then homogenized. This procedure was consistent with MTCA protocols [WAC 173-340-740(7)(d)].The sieved and homogenized sample was returned to the sample container and a sub sample was taken for the analysis. The portion of the sieved homogenized material that was not needed for the primary analysis was returned to the original container. The samples were then prepared using a microwave digestion technique (USEPA SW 846 Method 3051A) (USEPA 1998). Total arsenic and lead in the soil samples was analyzed by ICP-mass spectrometry (ICP-MS) (USEPA Method 6020). The reporting limits (RL) for this project were the practical quantitation limits (PQL). The PQL for the ICP-MS method is 1.0 mg/kg for arsenic and 0.5 mg/kg for lead. The laboratory method detection limits (MDL) for ICP-MS are approximately 0.2 mg/Kg for arsenic and 0.02 mg/Kg for lead. Since these limits are lower than the PQL, these methods of analysis were expected to be sufficient for the purposes of this project.

4. DATA QUALITY

4.1 Decontamination

The tools were decontaminated in a solution of Alconox © and water. A sprayer filled with deionized water was used to triple rinse the tools. The rinse water fell to the ground. The wastewater from washing the tools was discarded on site, away from the sampling area. Tools were allowed to air dry.

4.2 Field Duplicates

One field duplicate was collected for every 20 samples, approximately 5% of the total samples, to assess field sampling precision. The coring tool was driven into the soil; the soil was then placed in a gallon

Ziploc bag. The sample was mixed for at least thirty seconds to homogenize the contents. It was then split between a primary and a duplicate sample and submitted to the laboratory to be analyzed as two separate samples. Ninety two duplicate samples were collected, 4.9 percent of the total samples.

Field rinsate samples were not collected which is in accordance with the study design plan.

4.3 Chain of Custody

Chain of custody forms were filled out for all samples submitted to the lab. The chain of custody form recorded the individuals in possession of the samples at all times. The samples were compared to the chain of custody upon receipt at the lab and any discrepancies were noted. If revisions to the chain of custody were required both the PHSKC staff and the lab staff were notified and corrections were made to all copies.

4.4 Laboratory Quality Assurance/ Quality Control

The laboratory quality control procedures used for this project are listed in Appendix B. Laboratory quality assurance procedures consistent with the QAPP requirements were followed. Method blanks, duplicate samples, and matrix spike/matrix spike duplicates were analyzed for each sample delivery group or one per 20 samples. Standard reference materials were analyzed for each sample delivery group or one per 20 samples. Initial and ongoing equipment calibrations were also performed.

4.5 Validation Results

Relative percent differences (RPDs) between the duplicates and original samples were calculated. Xxx of the duplicates (xx percent) did not meet the 50 percent target presented in the QAPP.

4.6 Data Assessment Procedures

Independent data validation quality control (QC) was not performed for the CUA Phase II soil sampling due to budgetary constraints and the informational nature of the data being collected. Public Health Seattle and King County (PHSKC) performed a modified Tier 1A validation using suggested protocols from the US Environmental Protection Agency document, *Region 9 Superfund Data Evaluation/validation Guidance* (i.e. R9QA/006.1).

The following QC elements were performed on all data packages received from the lab:

- Analytical holding times from summary forms
- Chain of custody (COC) and sample handling
- Analytical accuracy [i.e. matrix spike compounds and standard reference materials, expressed as percent recovery (%R)] from summary forms. All lab calculations were checked for accuracy by PHSKC.
- Analytical and field precision (i.e. comparison of duplicate sample results) expressed as relative percent difference (RPD) from summary forms. All lab calculations were checked for precision. RPD calculations were performed by PHSKC on all field duplicate samples.
- Reporting limits (RL's) [i.e. practical quantitation limits (PQL's)] from sample result summaries.

QC element findings and compliance:

- All analytical holding times and lab analysis met the QAPP requirement of ≤ 20 days.
- Summary forms indicated that samples were received in good condition and that COC's were in order. PHSKC found that some sample identification numbers were incorrectly recorded by the lab. The lab was contacted and corrections were made; revised electronic data deliverables (EDD's) and hardcopy forms were provided to PHSKC.
- The lab was required to run a matrix spike and lab sample duplicate for every 20 samples or extraction batch, whichever is greater. PHSKC submitted 1882 samples to the lab and 109 matrix spikes (MS's) and sample duplicates were analyzed. The percentage of MS's and sample duplicates was 5.79%, which exceeded the minimum requirement of 5%. All MS's achieved the QAPP analytical accuracy requirements within the range of 75%-125% recovery. Likewise the lab duplicates met the QAPP analytical precision objective of ≤ 35% relative percent difference (RPD).
- PHSKC was required to submit 1 field duplicate per 20 samples collected. PHSKC performed the field precision calculations for RPD on all field duplicate samples submitted to the lab. The RPD objective for field duplicates was ≤ 50%. This objective was not met for 6 of the 92 duplicates collected. The table that follows gives a summary of the duplicate analysis performed by PHSKC.
- The QAPP reporting limits for this project were 1.0 mg/kg for Arsenic and 0.5 mg/kg for Lead. Five of the samples analyzed for lead had RL's greater than the 0.5 mg/kg objective. The RL's ranged from 0.511 mg/kg to 0.815 mg/kg. All of the sample results were above the RL's with a range of 10.5 mg/kg to 346 mg/kg. Four of the samples with RL's above the QAPP were below MTCA and one sample was above MTCA. The elevated RL's did not change whether the final result was above or below MTCA. The RL's for arsenic samples did not exceed the QAPP requirement.

Table 1

Average Relative % Difference Between Field Duplicates							
			Mean Relative % Difference				
# of Samples	**# of Duplicates**	**% Duplicates**	**Ar**	**Pb**	**Overall Mean**	**Samples above QAPP**	**% of Samples Above QAPP**
1882	92	4.89	9.13	11.08	10.10	6	6.52

5. RESULTS

Twenty seven of the 91 properties sampled, 29.7 percent, had samples with results above MTCA. Ninety eight of the 1882 samples collected had arsenic and or lead above MTCA, 5.2 percent of the total samples collected. The maximum arsenic and lead concentrations were 223 mg/kg and 660 mg/kg, respectively. The background level of arsenic is reportedly approximately 10 mg/kg (Glass, 2003). The state cleanup levels (MTCA) are 20 mg/kg arsenic and 250 mg/kg lead. Maximum arsenic and lead concentrations are shown mapped in Figure 1 and in graphical representations, Figures 2 and 3.

Figure 1. Results Map (Peter to provide)

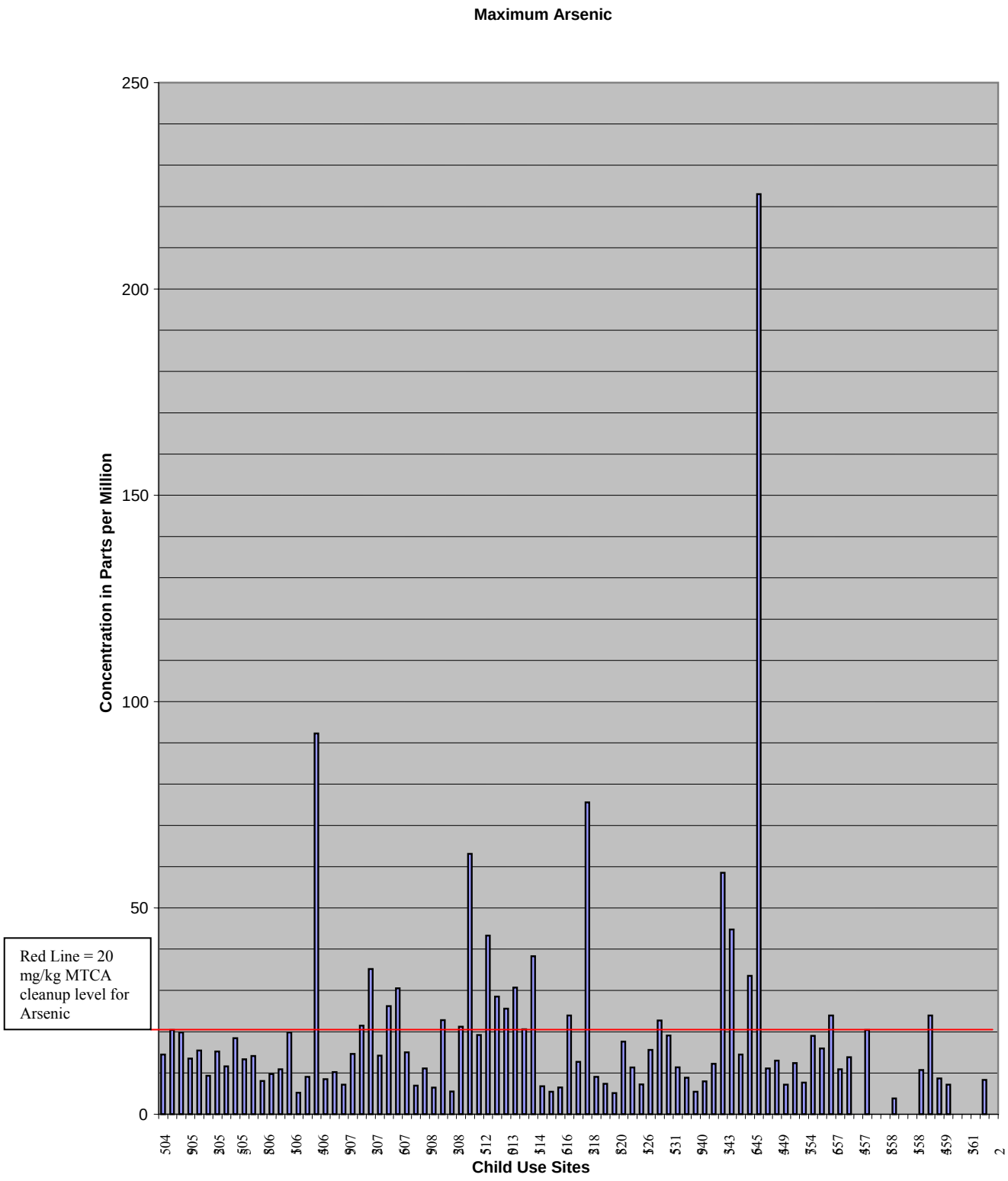

Figure 2. Graphical Representation of Arsenic Results,

See Tables 7 and 8, and Appendix B for Listing of Results

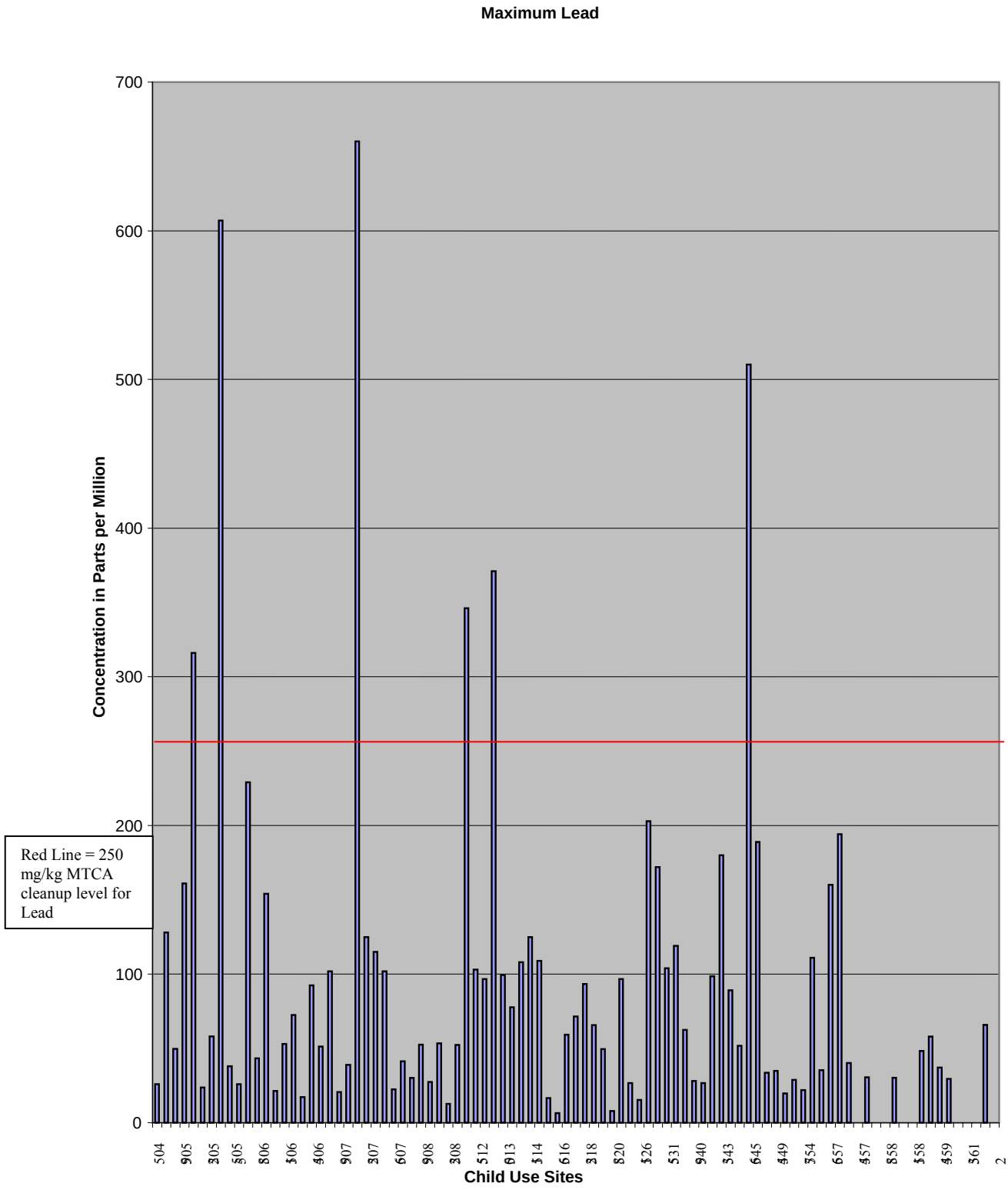

Figure 3. Graphical Representation of Lead Results

See Tables 7 and 8, and Appendix B for Listing of Results

The maximum arsenic concentration of 223 mg/kg was from the 0-2 inch depth of boring one (i.e. decision unit C) from site 5579. The 2-6 inch sample from that boring contained 14.5 mg/kg arsenic. Thirty eight samples were collected at that property; four other samples had arsenic levels above MTCA (i.e. 47.9 mg/kg, 50.8 mg/kg, 99.3 mg/kg, and 198 mg/kg). The remainder of the samples were below MTCA. The maximum lead level at that property was 189 mg/kg.

Eight properties had five or more samples with arsenic concentrations above MTCA as shown in Table 4. In addition to having five or more samples with arsenic above MTCA, Sites 5578 and 5123 also had samples with lead above MTCA. Site 5578 had seven samples with arsenic concentrations above MTCA, and two samples with lead above MTCA. Site 5123 had nine samples with arsenic concentrations above MTCA, and one sample with lead above MTCA. Twenty five of the 91 sites sampled had arsenic results above MTCA.

Table 4. Sites with Five or More Samples with Arsenic Above MTCA

Site Number	# Samples with Arsenic >MTCA/Total # Samples
5076	6/12
5123	9/16
5181	8/10
5574	13/64
5576	7/32
5578	7/16
5579	5/38
5593	5/10

Site 5075 had six samples with lead results above MTCA and one sample with arsenic concentrations above MTCA. The results for the six samples above MTCA were:

15.7 mg/kg arsenic; 624 mg/kg lead

21.5 mg/kg arsenic; 660 mg/kg lead

16.3 mg/kg arsenic; 368 mg/kg lead

14.3 mg/kg arsenic; 264 mg/kg lead

17.4 mg/kg arsenic; 455 mg/kg lead

18 mg/kg arsenic; 347 mg/kg lead

The ratio of lead to arsenic from the Asarco Smelter is generally approximately 2 ½ lead: 1 arsenic. The samples collected at Site 5075 do not closely match that general Asarco Smelter signature ratio of lead to arsenic indicating another possible source for the contamination other than Asarco.

Averages were calculated to compare concentrations for the different depth intervals, 0-2 inch and 2-6 inch. The average arsenic concentration for all samples was 9.1 mg/kg at 0-2 inches and 7.7 mg/kg at 2-6 inches. The average lead concentration for all samples was 27.1 mg/kg at 0-2 inches and 23.85 mg/kg at 2-6 inches. These averages show slightly higher concentrations of both arsenic and lead in the surficial 0-2 inch depth samples than in the 2-6 inch depth samples. Sample summaries for properties above and below MTCA are shown in Tables 5 and 6. Tables 7 and 8 present arsenic and lead results for properties with results above MTCA by depth interval and boring number. Results for properties below MTCA can be found in Appendix B.

Table 5. Sample Summary for Properties with Results Above MTCA

27 Properties Results Above MTCA	
Arsenic Results	**Lead Results**
Maximum arsenic 223 mg/kg	Maximum lead 660 mg/kg
85 samples from 25 properties >MTCA	13 samples from 6 properties >MTCA
0-2 inch average arsenic 13.6 mg/kg	0-2 inch average lead 39.0 mg/kg
2-6 inch average arsenic 10.6 mg/kg	2-6 inch average lead 32.0 mg/kg

Table 6. Sample Summary for Properties with Results Below MTCA

64 Properties with Results Below MTCA			
Arsenic Results		**Lead Results**	
0-2 inch average arsenic	4.5 mg/kg	0-2 inch average lead	15.1 mg/kg
2-6 inch average arsenic	4.8 mg/kg	2-6 inch average lead	15.7 mg/kg

Table 7. Arsenic Results for Properties with Results Above MTCA

TABLE 7

Site #	Max. As mg/kg	Max. Pb mg/kg	As >MTCA/# Total Samples	Decision Unit A Boring #1		Boring #2		Boring #3		Boring #4		Boring #5		Boring #6		Boring #7		Boring #8	
				0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"
				As	As	As	As	As	As	As	As	As	As	As	As	As	As	As	As
5050	**20.4**	128	**1/16**	16	14	19	**20**	6.5	11	12	14								
5053	**20.4**	30.6	**1/6**	**20**	21	13	24	31	24	25									
5054	15.4	**316**	0/10	15	9.4	9.3	6.4	8.5	11	5.3	8.8	15	8.9						
5057	11.6	**607**	0/14	2.4	8.4	8.1	7.5	5.6	8	9.4	8.5	7.9	7.4	4.7	8.9	9.4	12		
5069	**92.3**	92.5	**3/28**	7	9.6	**71**	**92**	5.9	8.3	4.2	3.9	5.2	7.6	10	11	12	12		
5075	**21.5**	**660**	**1/12**	16	17	16	**22**	18	20	16	14	16	19	17	18				
5076	**35.2**	125	**6/12**	**25**	**35**	**21**	**32**	**24**	9.4	16	9.2	15	18	19	**22**				
5078	**26.2**	102	**1/8**	12	14	7.6	**26**	9.9	13	9.7	12								
5079	**30.5**	22.6	**1/12**	6.9	7.5	5	5.8	**31**	9.7	9.7	7.4	7.5	7.9	5.5	7.4				
5095	**22.8**	53.4	**1/18**	9.4	7.8	**23**	20	6.4	5.8										
5122	**21.2**	52.4	**3/62**	6	4.6	5.9	11	9.3	10	3.9	10	13	13	**21**	13	**21**	**21**		
5123	**63.1**	**346**	**9/16**	**63**	**40**	3.5	7.2	6.6	7.8	**22**	**27**	**45**	**29**	5.2	8.4	**26**	**37**	18.2	**42**
5134	**43.3**	96.7	**2/10**	15	18	16	**43**	15	17	11	12	10	**21**						
5135	**28.5**	**371**	**2/6**	19	17	**29**	7.4	**20**	9.2										
5146	**25.6**	99.5	**1/16**	16	16	12	15	14	9.8	18	11	17	11	12	11	16	4.9	15.7	**26**
5157	**30.7**	77.7	**2/12**	15	16	5.4	15	18	18	18	14	8.9	15	**31**	**27**				
5159	**20.6**	108	**1/14**	**21**	12	14	15	11	13	15	15	4.9	16	9.9	12	12	16		
5181	**38.3**	125	**8/10**	**24**	**25**	**34**	**31**	**34**	**35**	**33**	**38**	18	16						
5201	**23.9**	59.2	**1/14**	7.6	6	11	5.2	9.2	5.7	**24**	14	10	6.7	13	7.5	6.9	6.2		
5245	**23.9**	57.9	**1/6**	13	24	3.4	17	8.2	11										
5318	**75.6**	93.4	**2/8**	2.7	3.9	8.8	8.9	6.5	9.5	**31**	**76**								
5457	**22.7**	172	**1/28**	5.8	4.8	4.1	5.1												
5574	**58.5**	180	**13/64**	5.2	4.6	8	4.2	3.5	2.6	8.3	16	9.1	11	4.3	4	4.5	3.7	14.1	**26**
5576	**44.8**	89.2	**7/32**	**20**	**24**	**45**	**25**	9.9	11	**21**	11	9.4	13	14	16	16	18	8.74	3.2
5578	**33.5**	**510**	**7/16**	13	11	18	6.1	13	17	17	**21**	**29**	**25**	**26**	**25**	**34**	**24**	10.7	11
5579	**223**	189	**5/38**	5.7	4.5	4.3	3.5	10	5.5	4.4	5.8	4.4	4.2	5	3.4	2.2	6.1	1.68	4
5593	**23.9**	160	**5/10**	12	11	19	**22**	19	16	**24**	**22**	**23**	**22**						
			85 samples with arsenic >MTCA																
25 sites with arsenic results >MTCA																			
Arsenic Averages for sites with results >MTCA:																			
0-2"	13.56																		
2-6"	10.56																		

Site #	Decision Unit B Boring #1		Boring #2		Boring #3		Boring #4		Boring #5		Boring #6		Boring #7		Boring #8	
	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"
	As	As	As	As	As	As	As	As	As	As	As	As	As	As	As	As
5050	6.2	6.9	6	6	5.4	6.2	8	8.6								
5069	9	**28**	9.2	11	6.8	13	4.4	12	5.3	7.5	7.7	9.7	8.4	9.8		
5095	4.2	4.5	6	5.9												
5122	4.5	1.7	5.4	2.4	4	1.9	9.2	4.8	8.9	7.5	11	2.5	3.2	8	3.8	7.8
5457	8.3	11	2.8	3.3	12	11	14	6.2	11	7.3	10	11	14	15	**23**	12
5574	2.2	1.7	1.7	1.7	2.2	1.5	4.5	4	3	2.9	2.9	3	3.7	3.3	3.3	1.7
5576	8	7.1	10	12	5.3	9	5.2	5.3								
5579	2.8	0.2	3.3	6.1	2.8	3.5	4.4	6	6.9	9.8	3.2	2.5	5	2.8	4.6	6.9

Site #	Decision Unit C Boring #1		Boring #2		Boring #3		Boring #4		Boring #5		Boring #6		Boring #7		Boring #8	
	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"
	As	As	As	As	As	As	As	As	As	As	As	As	As	As	As	As
5095	3.8	5.3	4.8	10	18	7.5	6.7	6.5								
5122	3.9	5	2.7	8.3	3.4	20	5	9.1	6.6	7.8	3.5	6.9	3.5	11	2.9	2
5457	5	5	3.8	4.8	4.2	4.8	5.4	4.5								
5574	3.2	7	4.9	6.2	**32**	**37**	4.3	3.9	6.9	4.8	4.7	4.7	**22**	**23**	8.5	4.5
5576	16	7.5	10	7.9	7.1	3.5	**44**	**29**								
5579	**223**	15	**99**	**48**	**198**	**51**										

Site #	Decision Unit D Boring #1		Boring #2		Boring #3		Boring #4		Boring #5		Boring #6		Boring #7		Boring #8	
	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"
	As	As	As	As	As	As	As	As	As	As	As	As	As	As	As	As
5122	3.9	7.2	4.1	6.6	3	3	3.3	5.1	3.5	4.8	3.6	7.5	3.6	7.6	3.9	4
5574	**59**	18	**24**	13	**28**	5.8	**30**	**23**	**21**	11	**25**	**26**	5.3	5.1	16	4.9

Table 8. Lead Results for Properties with Results Above MTCA

TABLE 8

Site #	Max. As mg/kg	Max. Pb mg/kg	Pb >MTCA / # Total Samples	Decision Unit A Boring #1		Boring #2		Boring #3		Boring #4		Boring #5		Boring #6		Boring #7		Boring #8	
				0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"
				Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb
5050	**20.4**	128	0/16	119	78.8	126	128	54	118	63	73								
5053	**20.4**	30.6	0/6	21	12.8	24	30.6	24	25										
5054	15.4	**316**	**1/10**	**316**	83.7	55	31.1	55	44	39.3	102	143	25						
5057	11.6	**607**	**1/14**	6.4	35	79	13.7	**607**	45	92.5	9.8	25.9	24	11.9	22.3	45	41		
5069	**92.3**	92.5	0/28	31	46.7	65	76.1	19	32	14.3	14	16.4	26	47.5	50	65	93		
5075	**21.5**	**660**	**6/12**	239	220	**624**	**660**	182	129	**368**	**264**	149	129	**455**	**347**				
5076	**35.2**	125	0/12	99	84.6	88	125	85	18	67.9	31	58.7	64	63.1	47.2				
5078	**26.2**	102	0/8	77	35.5	43	77.5	56	37	102	43								
5079	**30.5**	22.6	0/12	19	17.5	18	14	20	16	20.7	18	22.6	22	12.8	20.8				
5095	**22.8**	53.4	0/18	37	37.7	37	39.4	51	53										
5122	**21.2**	52.4	0/62	42	27.8	12	25	19	19	9.62	31	36.1	28	39.2	24.2	52	44		
5123	**63.1**	**346**	**1/16**	171	118	13	34.9	18	21	56.6	84	127	37	6.47	5.76	95	62	167	**346**
5134	**43.3**	96.7	0/10	79	57.6	58	53.4	92	94	82	79	72	97						
5135	**28.5**	**371**	**2/6**	219	61.5	**371**	43.4	**268**	45										
5146	**25.6**	99.5	0/16	52	49	53	59.3	55	25	99.5	27	70.3	22	77.6	38	53	7.1	81	28.7
5157	**30.7**	77.7	0/12	35	28.5	10	32.5	51	44	43.1	33	19.1	36	77.7	58.8				
5159	**20.6**	108	0/14	59	23.7	56	18.2	78	87	108	44	21.3	75	30.4	44.9	69	22		
5181	**38.3**	125	0/10	70	64.5	104	94.9	103	102	125	100	45.5	42						
5201	**23.9**	59.2	0/14	19	11.3	25	9.51	21	12	59.2	32	32.4	16	19.5	9.58	14	10		
5245	**23.9**	57.9	0/6	27	25.8	28	57.9	27	28										
5318	**75.6**	93.4	0/8	11	8.84	31	29	23	23	43.7	93								
5457	**22.7**	172	0/28	19	7.93	15	24.1												
5574	**58.5**	180	0/64	11	9.98	25	8.06	12	4.3	26.2	34	32.7	39	11.6	9.45	8.6	6.8	43	40.1
5576	**44.8**	89.2	0/32	28	44	44	37.2	18	19	38.4	10	23.2	33	38.7	39.4	47	56	21	6.04
5578	**33.5**	**510**	**2/16**	44	24.1	42	10.2	35	36	56.2	78	18.8	35	**253**	**510**	82	58	36	28.6
5579	**223**	189	0/38	19	20.4	9.9	11.7	21	20	12.1	19	19.6	17	13.4	10.2	8.2	21	2.4	5.99
5593	**23.9**	160	0/10	37	31.2	138	160	78	60	96.9	92	107	109						
			13 samples with lead >MTCA																
6 sites with lead >MTCA																			
Lead Averages for sites with results >MTCA:																			
0-2"	39																		
2-6"	32.1																		

Site #	Decision Unit B Boring #1		Boring #2		Boring #3		Boring #4		Boring #5		Boring #6		Boring #7		Boring #8	
	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"
	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb
5050	31.1	44.5	30	34	37.2	68	32	36								
5069	14.2	38	42	50	16.4	30	9.2	55	8.71	31.8	20.2	28.6	37.1	41.8		
5095	16.9	17.4	37	26												
5122	6.28	1.92	7.3	3.1	5.39	2.4	15	7.6	14.4	11.6	19.8	3.44	5.72	6.88	6.06	9.4
5457	32.8	43.1	4.8	17	42.8	51	62	17	59.1	24.9	44	36.1	145	145	172	56
5574	3.98	2.87	4.7	4.2	7.52	2.1	14	8.9	8.28	5.44	9.27	6.48	8.75	5.57	6.31	2
5576	15.1	13.4	89	29	12.8	22	12	11								
5579	11.9	0.359	20	7.7	3.57	6.3	14	18	40.1	34.5	9.52	3.9	20.6	7.21	25.5	31

Site #	Decision Unit C Boring #1		Boring #2		Boring #3		Boring #4		Boring #5		Boring #6		Boring #7		Boring #8	
	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"
	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb
5095	11	22.8	21.3	37	30.5	32	28	25.1								
5122	4.5	10.9	2.56	13	3.97	35	14	27	13	16	10.9	15	5.6	21	4.8	2.7
5457	14	13.3	11.2	11	18.1	22	18	12.9								
5574	8.6	23.8	10.1	14	67.3	78	11	8.74	18	11	10	8.5	49	38	18	21
5576	29	13.8	23	18	15.9	6.2	15	17.2								
5579	189	11.9	91.3	35	187	47										

Site #	Decision Unit D Boring #1		Boring #2		Boring #3		Boring #4		Boring #5		Boring #6		Boring #7		Boring #8	
	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"	0-2"	2"-6"
	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb	Pb
5122	9.6	11.5	22	11	9.4	7.8	9.8	11.3	9.91	9.2	9.2	12	9.3	11.7	10.2	8.93
5574	79	20.5	46	32	60	7.3	77	59.9	40.5	16	80	180	31	16	35.9	8.8

6. CONCLUSIONS AND RECOMMENDATIONS

Based on our studies and observations, the following conclusions were drawn which are in general consistent with previous studies.

6.1 Concentrations

Twenty seven of the 91 properties sampled, nearly 30 percent, had arsenic and or lead results above cleanup levels. Arsenic was detected above the state cleanup level of 20 mg/kg in 5.2 percent of the samples collected. The maximum arsenic concentration reported was 223 mg/kg. Lead was detected above the state cleanup level of 250 mg/kg in less than one percent of the samples collected. The maximum lead concentration reported was 660 mg/kg.

Slightly higher concentrations of both arsenic and lead were found in the surficial 0-2 inch depth samples than in the 2-6 inch depth samples. The average arsenic concentration for all samples was 9.1 mg/kg at 0-2 inches and 7.7 mg/kg at 2-6 inches. The average lead concentration for all samples was 27.1 mg/kg at 0-2 inches and 23.85 mg/kg at 2-6 inches.

Eight properties had five or more samples with arsenic concentrations above MTCA.

Six samples with lead above MTCA and one sample with arsenic above MTCA were collected at Site 5075. The ratio of lead to arsenic in those samples is greater than the approximate Asarco ratio of 2½ lead: 1 arsenic. It is possible the contamination identified at Site 5075 is from a source other than Asarco.

6.2 Geographic Distribution

Large scale spatial patterns of elevated concentrations of arsenic and lead in soil caused by air deposition from the Tacoma Smelter, were found to be variable on a local scale, areas of 0-20 mg/kg are intermixed with areas 20-100 mg/kg.

6.3 Letters to Property Owners

Letters were sent to property owners listing the laboratory results for samples collected on their property. The letter also described the state cleanup levels, the health risks, and soil safety guidelines developed by PHSKC. The guidelines advise property owners of precautions to reduce risk of exposure to contaminated soil. Contact telephone numbers of Ecology and PHSKC staff were provided in the letter to property owners who desire further guidance.

6.4 Recommendations

Samples were collected from 91 child use areas in this Phase II CUA sampling effort where approximately 600 child use areas were initially identified. Given that contamination was identified on approximately 30 percent of the properties sampled and that there are a significant number of child use areas that have not been sampled, it is reasonable to assume that a significant risk of exposure to children and the public still exists within the TSP. It is our recommendation that sampling, education and outreach efforts to child use areas and owners be continued.

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APPENDIX A
LABORATORY QC PROCEDURES

Metals by ICP/MS

C Parameter	Minimum Frequency	Acceptance Criteria	Corrective Action
thod Blank	Every 20 samples or extraction batch, whichever is more frequent.	Absolute value of blank result < RL) or the associated samples must be greater than 10 times the blank concentration.	Reanalyze and/or re-extract associated samples.
ial Instrument Calibration	Curve must be made of at least a blank plus 1 standard, at initiation of analytical sequence, every 24 hours, or as needed.	Correlation coefficient (r) $\geq$ 0.995 if more than one standard analyzed.	Reanalyze associated samples.
ial Calibration Verification ndard (ICV)	ICV must be analyzed immediately after analysis of the calibration curve and before the analysis of samples.	%D between the true and the measured values $\leq$ 10%.	Stop analysis and reanalyze calibration curve.
ntinuing Calibration rification Standards (CCVs)	CCVs must bracket 10 analyses.	%D between the true and the measured values $\leq$ 10%.	Reanalyze samples not bracketed passing CCVs.
ial Calibration Blank (ICB)	ICB must be analyzed immediately after analysis of the ICV and before the analysis of samples.	Absolute value of blank result < IDL or the associated samples must be greater than 10 times the blank concentration.	Reanalyze all associated samples 10 times the blank concentration.
ntinuing Calibration Blanks CBs)	CCBs must bracket 10 analyses.	Absolute value of blank result < IDL or the associated samples must be greater than 10 times the blank concentration.	Reanalyze all associated samples 10 times the blank concentration.
ernal Standards	Minimum of three per sample.	Percent recovery of internal standards must be greater than 30% of the intensity of the internal standards in the initial calibration standard.	First, check for instrument drift; terminate analysis, correct problem and reanalyze all samples since las in control CCV/CCB. If no drift, dilu sample and reanalyze.
ndard Reference Materials RMs)	Every 20 samples or extraction batch, whichever is more frequent.	Analyte results must be within the manufacturers certified acceptance limits.	Re-extract and reanalyze associate samples.

Metals by ICP/MS (Continued)

C Parameter	Minimum Frequency	Acceptance Criteria	Corrective Action
trix Spike (MS)	Every 20 samples or extraction batch, whichever is more frequent.	Where the native sample concentration is less than 4 X the amount spiked, the %R must be 75% to 125%. For analytes where the native sample concentration is greater than 4 X the amount spiked, no evaluation will be made.	Consult with Chemistry QA Officer corrective action.
mple Duplicate	Every 20 samples or extraction batch, whichever is more frequent.	Where the concentration in the sample and duplicate is > 5 X RL, the RPD ≤ 20%. If either the sample or duplicate result is < 5 X the RL, the difference in the concentrations must be less than 2 X the RL.	Consult with Chemistry QA Officer corrective action.
rial Dilution	Every 20 samples or extraction batch, whichever is more frequent.	For analytes where the concentration in the sample is > 50 times IDL, the %D ≤ 10%.	Consult with Chemistry QA Officer corrective action.

APPENDIX B
LABORATORY RESULTS BELOW MTCA